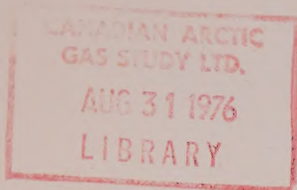


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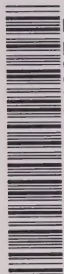
MACKENZIE DELTA GAS DEVELOPMENT SYSTEM

VOLUME 5

ENVIRONMENTAL STATEMENT

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VOL. 5

ENVIRONMENTAL STATEMENT

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I. SUMMARY AND CONCLUSIONS

Following the discovery of natural gas in the Mackenzie Delta in 1971, Imperial Oil Limited initiated an environmental protection program as an integral part of planning for the possible development of the resource. This program was primarily conducted by a consultant firm, F.F. Slaney & Company. Subsequently, Imperial Oil, Shell Canada and Gulf Oil Canada (the Applicants) agreed to joint planning and research for the development of Mackenzie Delta gas, which included sharing the environmental program.

In conjunction with the environmental consultant, a study-area concept was developed based on locations of exploratory well sites, staging areas and gravel deposits. The general area included in the investigation extended from Parsons Lake in the east to contiguous areas in a large segment of the outer Mackenzie Delta, encompassing Ellice-Langley, Richards Island and the Barrier Islands. Local areas with a high likelihood of concentrated development activity, or where the inhabitants relied on certain resources, were given special emphasis in the environmental analysis.

Environmental studies to establish base-line data from which to assess the effects of the proposed development began in 1972 and have extended into 1974. All major components of the physical and biological environment were investigated under the general categories of: Meteorology and Climate, Hydrology, Birds, Mammals, Land and Vegetation, Aquatic Resources, and Environmental Quality. While the environmental programs were proceeding, the Applicants were formulating plans and design concepts for development of Mackenzie Delta gas reserves. In the early stages of design the Applicants' planning engineers kept in close touch with the environmental consul-

tants in order to work out the best methods of protecting the environment. Among the measures to be implemented for both long- and short-term environmental control were monitoring and surveillance for pollutants and environmental degradation, environmental training for the labour force, and contingency plans to take care of oil spills, etc. The environmental consultant then made a final assessment of the proposed development in terms of its total effect on the arctic environment.

The assessment was based on the location and design of permanent facilities and development activities associated with the drilling, production, gathering and processing of the natural gas in the three potential gas fields designated as the Taglu, Niglintgak and Parsons groups.* Over six thousand possible interactions between features of the Mackenzie Delta environment and the proposed gas-development activities were examined. Most of the possible interactions were judged unlikely to produce significant effects. The main conclusions of the impact assessment were:

1. The consequences of unavoidable drainage alteration would be slight.
2. Careful siting of roads and facilities, and the use of gravel and other insulating materials, would provide maximum protection against soil erosion, slope instability, and thermokarst.
3. The presence of man and his machines might discourage the more wary and inflexible species of birds and mammals from using habitats close to roads and facilities. Most critical bird habitats, however, are some distance from the scene of proposed construction and would be unaffected.
4. Reindeer would be expected to adjust to facilities and activities.

A slightly more intense herding once every few years would be the worst that could be anticipated.

* Outlined in Volume 1.

5. The fur harvest for trappers from the local communities should not be affected.
6. The proposed development would disturb only very local segments of the terrestrial system. No major ecological subsystem should be upset.
7. No future opportunity for the use of existing renewable resources would be lost as a result of the development project.

II. BACKGROUND

A. INTRODUCTION

The Applicants have been exploring for hydrocarbons in the Mackenzie Delta area for about a decade. Planning for development and production began shortly after the test of an exploration well, drilled in 1971, indicated that the area might contain commercially exploitable reserves of natural gas.

The Canadian Government has proclaimed priorities for northern development, listing environmental protection second only to social improvement. The Applicants agree that social and environmental considerations are of fundamental importance.

Early in 1972, when concepts for the gas-development project began to be formalized, the Applicants commissioned an experienced Canadian environmental consulting firm to advise them on the likely effects of the proposed project and help them plan facilities and programs that would cause the least disturbance of the Mackenzie Delta environment.

B. APPLICANT RESPONSIBILITIES

The responsibilities of the Applicants in the area of environmental protection are:

- a) To ensure that their operations are compatible with the environment.
- b) To implement whatever environmental studies are necessary to adequately predict environmental changes resulting from the proposed development.
- c) To ensure an extensive interchange of information between their engineers and design planners and the environmental consultants, so that possible adverse environmental effects from their proposed operation would be either avoided or within acceptable limits.
- d) To undertake a program of monitoring during construction and long-term operation of the development.
- e) To work with all levels of government in developing new regulations that may be required to deal with environmental problems as they arise.
- f) To restore all areas of operation, upon leaving, as nearly as practicable to their natural state.

III. ENVIRONMENTAL PROGRAMS

A. PLANNING

To obtain the necessary basic environmental information, which was unavailable from other sources, the Applicants initiated extensive field studies. Environmental field work began in May 1972 and continued through until May 1974. General objectives of the field programs were: to determine the primary characteristics of ecosystems and natural resources; to develop an understanding of certain basic ecological relationships; to determine the type and extent of resource utilization by humans, and to provide a factual basis for projections of the type and extent of environmental impact, as well as optimum designs of facilities and programs.

Initially, the Applicants drew up a preliminary gas-development plan and used the matrix concept to predict possible interrelationships in order to select the environmental elements to be studied. Field work priorities were decided on the basis of a preliminary assessment of the significance of the natural resources in terms of value to people - particularly local people. A study-area concept was developed, for areas the Applicants felt were most likely to be affected by gas production. They included sites for processing plants, drilling and producing clusters, transportation/pipeline corridors, stockpile and staging areas, and borrow pits. Generally, the environmental field work was concentrated in the areas where greatest impact was anticipated. As exploration drilling and production planning proceeded, the areas of potential impact shifted, and the environmental field program was hence altered to conform to the revised concepts. Field studies extended over two years, with at least a year's continuous data collection from each area.

While the environmental programs were proceeding, the Applicants were formulating plans and design concepts for developing Mackenzie Delta gas reserves. They maintained liaison with the environmental consultant through their own designated representative and the consultant's project director. Formal meetings were held at least once a month to coordinate activities and monitor progress.

In the final stages of the field program, as the environmental data were being analysed and reports were being written, the Applicants' planning engineers held formal and informal meetings with the consultant's scientists. Early in 1974, the Applicants drew up a draft project description to which the consultant responded with suggestions, comments and recommendations of measures that could mitigate environmental impact. Virtually all of these were incorporated in the Applicants' plans after they had assessed technical and economic implications. Changes in design are more easily and economically implemented during the planning stage than at the later stages of detailed design, construction and operation.

When field work was starting in the spring of 1972, the plans for the environmental field program were reviewed with the Land Use Committee of the Department of Indian and Northern Affairs (DIAND). An interim data report was prepared and published in January 1973. This interim report received wide circulation and was presented formally to the Land Use Committee in Yellowknife, in February 1973. It was specifically reviewed by several other government agencies, including the Department of the Environment (DOE) Canadian Wildlife Service. Response to the interim report helped the Applicants to derive the most benefit from their effort during the final year of the studies.

A thorough search of scientific literature was maintained to supplement data gathered in field studies. Published journals, reports, and papers were reviewed, as well as some unpublished documents held by universities and government agencies.

B. FIELD PROGRAMS

1. Meteorology and Climate

The primary objective of this program was to determine the local climate at three sites and relate their individual climates to historical records collected at nearby government weather stations. The meteorological parameters studied were air temperature, wind speed and direction. Vertical distribution of each was studied at one location.

Most of the northern Mackenzie Delta lies within the Marine Tundra Climatic Zone and is characterized by long, cold winters and short, cool summers. The annual temperature variation in the study area was great: summer maxima near 80°F and winter minima near -50°F were recorded.

The wind distribution across the Delta is partially affected by local topography, but tends to display a predominant northerly component in the summer-fall and an easterly component in winter-spring. Mean monthly winds are highest in summer-fall and lowest in winter-spring. Yearly average speeds vary from 6 mph at Inuvik to more than 10 mph along exposed coastal areas.

Average annual totals of precipitation across the Delta are generally light. In general, areas close to higher topographic features (Inuvik, 11.15 inches/year) experience greater precipitation than lower coastal areas (Tuktoyaktuk, 5.32 inches/year). Both fog and cloud cover are highest during the break-up and freeze-up periods.

The microclimate or turbulent nature of the atmospheric boundary layer over the Delta surface was found to be quite unique compared with mid-latitude areas, in that it showed a high persistence of stable atmospheric conditions for nine months of the year. At the Taglu recording

station, ground-based inversions predominated from mid-September 1972 to June 1973.

2. Hydrology

The primary objective of this program was to determine the characteristics of water flow in three specific channels of the Mackenzie Delta and to observe snow melt and flooding. The surface hydrology is complicated by a great many interconnecting lakes and channels, varying channel contours, formation and development of extensive ice cover, and varying climatic influences. Of the three channels sampled in this program, East Channel would appear to carry the bulk of summer discharge water and Middle Channel about half as much. Harry Channel, because of its small size and shallower depth, shows much smaller summer discharges. In winter, Harry Channel flow was reduced to zero after critical ice depth was reached.

Spring flooding of Mackenzie waters and summer-storm surges occur each year to varying extents. The degree to which low-lying areas are affected by spring flooding is determined by maximum river stage and ice jamming. Areas affected by summer-storm surges are determined by the sustained maximum speed and prevailing direction of the winds, as well as the nearness of access to rising channels or sea water.

3. Landform and Vegetation

The main objectives of this program were to map the distribution of major vegetation within the study area, and determine the vegetation and soil characteristics of these mapping units; to identify physical and biological factors influencing vegetation; to indicate unique botanical phenomena within the study area, and to describe the study area's physical environment.

The Mackenzie Delta region is vegetated with three broad vegetation types - the forest region to the south, the treeless tundra to the north, and a tundra/forest transition between the two. The area of the proposed gas development project lies entirely in the tundra region, with the tundra/forest region reaching northward into the area in only few valleys. Base maps produced for the study area showed fourteen major vegetation units.

Most of the area is overlain by Pleistocene sediments of glacial, fluvial and marine origin. Turbid floodwaters inundate low-lying Delta areas during spring thaw and summer storms. Permafrost is widespread in the area and commonly forms an impermeable moisture barrier. Cryopedological processes are active, leaving a distinctive imprint on the landscape. Common features include patterned ground, drained lakes, pingos and thermokarst slumps. Vegetation reflects this mosaic assemblage of drainage, relief, and substrate stability.

Physiographic features and plant cover in lowland areas are relatively homogeneous. Plant communities in flood-plain areas are dominated by water-tolerant sedges and willows. In the lowest-lying areas sedges predominate, while slightly upraised areas, especially channel levees, support vigorous willow stands. Intermediate conditions are common, and are indicated by changes from sedge to willow communities.

Plant communities in upland areas reflect varied drainage patterns and are much more complex than those on flood-plain areas. Most communities are shrub-dominated. Poorly drained sites, where surface water is present, resemble the willow/sedge communities of flood-plains. Where drainage is poor but there is no surface water, cottongrass dominates characteristically tussocky terrain. Areas with drainage between the above

extremes are dominated by shrubs (birch, alder, and various heaths), ranging in growth form from extreme dwarfing to dense stands up to eight feet high.

4. Birds

The objective of this program was to determine the timing and distribution of bird populations, their relationships to habitat, and an estimate of their relative numbers. Emphasis was placed on those species thought to be endangered and those with particular economic, subsistence or aesthetic value.

During the study, 95 species of birds were observed with only 3 being permanent residents and the others migratory. Fifty-two species were found breeding in the area. Loons, waterfowl, shorebirds and seed-eating passerines made up the bulk of the recurrent bird species.

Spring migration was observed over two years. Peak rates of arrival were found to occur during the period from May 25 to June 1, and to vary in response to weather conditions that affected the availability of habitats. Areas of high use during migration included most of northern Richards Island's shoreline in floodplain areas and the mouth of East Channel.

Areas of intense use during nesting included colonial nesting sites on Richards Island and on near-offshore spits.

Areas used by moulting waterfowl included parts of Pelly Island, the area immediately south of Kendall Island, and an extensive region north of Dennis Lagoon.

Early in the fall, areas intensively used by migrant waterfowl were located generally along the northern delta coastline, but later, staging snow geese concentrated in the Shallow Bay area west of the study area.

Willow ptarmigan, rock ptarmigan, and common ravens were found wintering in the study area. Willow ptarmigan were most numerous and occurred in greatest densities in floodplain areas dominated by willows.

Utilization of bird resources by local inhabitants was found to be important in late winter and early spring, but less so in autumn. Hunting for waterfowl was concentrated along the shores of Shallow Bay to the west of the study area, with the bulk of the harvest in spring. Late winter hunting for ptarmigan was reported to be heavy in the Tununuk area.

5. Mammals

The primary objective of this program was to determine the abundance of mammals and identify and describe habitats that are important to them. Special attention was paid to species of high commercial, recreational, or subsistence value, and to rare and endangered species.

The mammalian fauna of the study area is impoverished as compared with that of areas farther south - only 15 species occur regularly. Because the "treeline" is nearby, several other species occasionally invade the region.

Until the early 1970's, Richards Island was a major summering area for reindeer. In 1972 and 1973, between 50 and 70 reindeer were seen there. The Parsons Lake area lies on the traditional traffic route between the summering and wintering areas. In 1973-1974 the herd wintered near Parsons Lake.

It is estimated that Richards Island has a population of two dozen grizzly bears. An additional nine were observed east of East Channel in the Parsons Lake area. Polar bears range along the coast in winter and are frequently hunted by the native population.

Muskrat are found in low densities only in the southeasterly portion of the study area. A few active beaver lodges were located in the vicinity of Parsons Lake.

Arctic ground squirrels were most abundant in dry, well-drained sand or gravel deposits.

The most common small mammal observed was the red-backed vole. Collared lemmings, brown lemmings and meadow voles are relatively rare.

Coloured foxes are common in the study area all year round. Arctic foxes migrate to the Richards Island area in winter.

Beluga whales are found in summer in the Mackenzie estuary. They were most commonly observed between late June and mid-August. Population estimate for 1972 was 2,000, for 1973 between 3,500 and 4,000.

6. Aquatic Resources

The objective of this program was to describe the channel, stream and lake ecosystems by identifying aquatic vertebrates and invertebrates, and learning of their distribution; describing basic physical and chemical parameters of aquatic habitat, and identifying aquatic resource use by people of the region.

Eighteen species of fresh-water fish were identified from the Delta, and of these, eight are used for commercial or domestic purposes (including human consumption and dog food).

Fish species found in channels include broad and humpback whitefish, inconnu, and arctic and least cisco. Channels were not identified as spawning areas; however, they may be migratory routes of some importance.

Streams in the Parsons Lake area are used as migratory routes, spawning areas and summer habitat by arctic grayling, and as summer habitat

by northern pike. Some of the Richards Island streams are important migratory routes for large populations of broad whitefish and migratory least cisco.

Humpback whitefish, least cisco, lake trout, northern pike and turbot are known to use lakes for spawning. Many lakes in the study area constitute suitable spawning sites.

The main varieties of fish collected in the East Mackenzie Bay estuary were arctic cisco, least cisco, inconnu, boreal smelt, and fourhorned sculpin. Fish were most abundant in semiprotected areas, and there are indications that some species may spawn in the estuary.

Ya Ya Lake on Richards Island, which supports a population of lake trout and is easily reached by river from Inuvik, is very popular with casual, local sports fishermen. Domestic fishing was observed at Holmes Creek, Kittigazuit, Whitefish Station, and Pelly and Kendall islands. Broad whitefish and inconnu were the main species caught and used. A commercial fishery for broad whitefish was carried on at Holmes Creek. The 1973 quota for this operation was 50,000 lbs of fish.

7. Environmental Quality

The objectives of this program were to spot-check certain basic parameters of air and water, and to determine natural levels of several elements in samples of plant and animal tissue, and in soil.

Air samples were tested for dustfall, suspended particulate matter, sulphation index, ozone, nitrogen dioxide, hydrogen sulphide and hydrocarbons. Water samples were tested for total organic carbon, ether extractable hydrocarbons, sulphate, total hardness, calcium, magnesium, alkalinity, pH, turbidity, conductivity and chlorides. Plant, animal and soil tests included copper, cadmium, lead, mercury, and sulphur.

8. Winter Study Supplement

The general purpose of the 1973-1974 winter program was to continue environmental data collection in new study areas encompassing a number of drill sites, the Swimming Point staging area, and some additional corridors.

IV. IMPACT ASSESSMENT

The environmental-impact analysis was based on biophysical data collected from May 1972 to May 1974, and a Summary Project Description provided by the Applicants. The consultant's professional personnel identified and evaluated significant interactions and projected the type and extent of environmental impact.

A. ATMOSPHERE

Construction machinery and routine road traffic would generate to the atmosphere small amounts of gaseous emissions, such as carbon dioxide, carbon monoxide, oxides of nitrogen, sulfur dioxide, sulfur trioxide, water vapour, heat and unburned hydrocarbons. Direct effects would be local only and would not significantly reduce air quality over the long term.

Dust and suspended particulate matter would be introduced into the atmosphere by vehicle movement and by scouring of all-weather roads during high winds. The settling of this material on surrounding snow cover would increase the rate of spring snow melt, but snowdrifts along the roadsides would offset this effect. Similar effects would occur around other permanent facilities.

Exhausts from barges and boats would be emitted in small concentrations that would not noticeably affect local air quality.

Full exhausts and disturbance of ground cover by moving aircraft and helicopters would cause small changes in the physical and chemical parameters of the air around ground facilities. Such effects should be localized and of short duration.

The gas plants might change the heat capacity and albedo of the plant site slightly. During calm sunny conditions, temperatures on the pad could rise several degrees higher than those in surrounding areas, causing small cumulus clouds to form above the plant. Water vapour emitted from the plants would locally form fog, reduce net radiation to the ground, and increase relative humidity. These effects might serve to increase hoar frost and ice crystals on surrounding ground cover. All such effects would be restricted to the vicinity of the plants. Under certain winter conditions, ice fog would build up near the plants. Such atmospheric effects should not harm the local environment.

The only source of long-term atmospheric effects from the gas plants might be turbines burning gas condensates. The main components of the exhaust would be carbon dioxide, oxygen, nitrogen, nitrogen oxides, water vapour, and possibly traces of sulfur dioxide. Excess air would be fed to the turbines to ensure complete combustion of the hydrocarbons.

To assess effects of the emissions on the local atmosphere, maximum concentrations of sulfur dioxide and nitrogen dioxide were calculated for the worst atmospheric conditions possible at two different times of the year for both plants. The models show that the ground concentrations of sulfur dioxide and nitrogen dioxide around the Taglu plant could conceivably reach .0067 ppm and 0.056 ppm respectively. At the Parsons Lake plant, ground-level concentrations for nitrogen dioxide could be slightly higher; sulfur dioxide has not been identified as an emission component.

Plant design would prevent liquid-hydrocarbon flaring. Gaseous hydrocarbons would be flared occasionally in emergencies and during plant start-up. Flaring would take place in a stack tall enough to ensure

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Plant design would prevent liquid-hydrocarbon flaring. Gaseous hydrocarbons would be flared occasionally in emergencies and during plant start-up. Flaring would take place in a stack tall enough to ensure

maximum dispersal of combustion products. The system design prevents the venting of hydrocarbons.

Exhaust emissions from engines and heaters at well clusters would be minimal and would not materially affect the local climate.

Incineration of solid refuse and waste would disperse some unburned material to the atmosphere during fire-up only. Any effect would be restricted to the immediate vicinity of the incinerator.

B. LANDFORM AND VEGETATION

Construction of the roads connecting well clusters and gas plants would alter drainage and flood patterns on some adjacent acreage, resulting in possible changes in vegetation type. In the Parsons Lake area, sections of road would traverse areas with a high potential for slumping. Design and construction would incorporate measures to avoid or minimize drainage redistribution or surface slumping.

Most vegetation under winter roads would die, although rhizomes would regenerate each summer.

Vegetation under airstrips, permanent pads, facilities and roads would be destroyed. However, in every case enough insulating material would be provided to maintain the integrity of the permafrost. The amount of terrain lost in this manner would represent a very small proportion of that available to vegetation types in the area.

Extracting gravel from esker ridges near Ya Ya Lake would destroy xeric gravel vegetation, which is limited in the development area. Natural revegetation on gravel sites would be extremely slow.

Plans for the construction, maintenance and use of drilling sumps have been designed to avoid any damage to surrounding vegetation.

In constructing the gathering systems, heavy equipment would destroy some surface vegetation on the right-of-way. Plants would be regenerated from the first summer, so that little or no thermal erosion should result.

Neither gas plant is expected to cause thermal erosion or changes in drainage patterns. Vegetation is not expected to be seriously affected by water vapour emitted during normal plant operations. Any increases in hoar frost, ice crystals, and fog formations adjacent to the plants should not be noticeable.

Nitrogen oxides emitted from the gas-plant turbines are not considered a major problem, as their worst-case levels would be well below what is considered toxic to vegetation.

Sulphur dioxide emitted to the atmosphere could damage vegetation. The possibility is a very remote one, however, since the maximum concentration of SO₂ that could originate from the Taglu gas plant just approaches the lowest possible level of SO₂ that can produce chronic symptoms in arctic lichens, the most sensitive of the plants. Since lichens are not noticeably present within three miles of the gas plant, no vegetation damage is anticipated.

No vegetation damage is expected from sulphur dioxide emissions from the Parsons Lake gas plant, as no sulfur has been recorded in the condensate.

Site reclamation would be conducted without damaging adjacent vegetation and landform. Disturbed areas and graded abandoned sites would be reseeded with fertilized native grasses, to ensure fast regeneration of the vegetative mat and thus avoid erosion and slumping.

In general, the proposed development should not have any extensive influence on vegetation and landform. Such impact as might occur would be local, consisting mainly in the destruction of ground cover by direct contact with vehicles and materials.

Where development activities affected drainage, there might be some secondary effect on vegetation, which would occur very gradually over the years.

Slope slumping, erosion and thermokarst have had to be considered as possibilities in nearly all the development activities. The development plans, however, include provision for detecting and preventing

the disturbance of unstable terrain, so that any problems that might occur would be minor and without serious effect.

C. HYDROLOGY

Installing permanent roads and other gravel-based facilities in the Taglu area would affect local drainage patterns. Culverts and proper positioning of roads would help minimize this effect by allowing freer passage of water.

In the Parsons Lake area, the proposed all-weather road system would cross some steep slopes and could hence pose a threat to drainage patterns and slope stability. Most road sections would pass through broad, diffuse drainage patterns where any resulting impediment would be temporary. There would be some additional siltation of streams and adjoining lakes, as well as some unavoidable slope erosion, but the use of bridges and culverts would minimize these effects.

Run-off from snow melt would contain silt from the gravel used for the permanent roads, airstrips and pads. This additional silting would occur in spring, when silt loads from natural sources are at their highest level and flows near their maximum. It is unlikely that any additional silt from this source, however, would pose a threat to fish-spawning beds.

Winter roads should disturb the terrain very little and hence would not be likely to disrupt the drainage.

Continued use of the gravel area at Ya Ya Lake would result in some siltation. Such effect, however, would be slight.

Minor channel dredging might cause local increases in suspended sediment. Such increases, however, would be overshadowed by naturally high sediment loads. Construction of field-gathering systems would produce localized and short-term effects on siltation and water movement at channel

crossing. As all construction and trenching would take place in winter, such effects would be minimal.

The water supply required for the gas plants would not affect the sources (Kuluarpak Channel for Taglu, Parsons Lake for Parsons Plant) or the local water table. Process waters from the gas plants and liquid wastes from the camp would be suitably treated before discharge to satisfy government standards. Excess heat from the discharged plant water might affect ice cover in the immediate vicinity.

D. BIRDS

The construction and use of permanent roads is not considered to threaten any species. During fall migration, large numbers of geese use the area just north of the Taglu gas plant and cluster sites, but few come inland as far as the proposed roads. Roads and vehicle movement in the Delta floodplain might affect some habitats of the Hudsonian godwit, but not to a significant extent. Ptarmigan winter habitats might be affected to a very minor degree.

Most dredging and boat traffic would be in large channels not used extensively by birds. Boat traffic would be restricted in small tributary channels used by moulting waterfowl.

Geese are the only group whose reactions indicate that they might suffer from aircraft overflights. Flight lines would be predetermined to avoid nesting areas and thus minimize any adverse effect.

The field gathering system would remove some avian habitat. Such damage would affect only small areas and impact on any species would be very minor. Some nests near the gathering system might be lost if routine aerial inspection flights frightened the incubating birds. Such flights would be reduced during breeding season to avoid any adverse effects.

Construction and operation of the gas plants would affect birds through direct loss of habitat, and the presence of men and equipment at each plant site.

Noise levels are not expected to adversely affect birds in the vicinity of the plants beyond the range of avian disturbance expected from other sources. Nesting and migrating geese are the most susceptible to high noise levels; however, the closest geese-nesting colony to a plant

(the Taglu site) is well outside the range within which gas-plant sound emissions should disturb them.

Any effect on birds from personnel activities could be expected to be minor, as the strict policies already enforced during exploration would be continued by the Applicants during construction and operation of the gas-production system.

In summary, the proposed development would affect birds by destroying or creating avian habitats and by disturbances preventing use of habitat. Habitats would be destroyed directly by the building of roads, gravel pads, docks, and airstrips over existing natural vegetation, while movement of men and equipment at these locations might prevent some species from using surrounding habitats. However, development plans as outlined to date would not impinge on any high-use areas as identified in the environmental study report, thus avoiding immediate major impacts at the outset. Other restrictions on activities, such as directed personnel movement and specific flight pathways, would also help to keep the effect on birds to a minimum.

E. MAMMALS

The construction and use of permanent roads would affect mammals by taking a small amount of land out of production, presenting an obstacle to movement, and disturbing more wary species through traffic and equipment noise. Reindeer should have little difficulty in crossing roads in the development area. Grizzly bears would probably avoid any area close to a travelled roadway. Grizzlies are particularly vulnerable in winter, when road construction and use might rouse them from their dens. Because of their low numbers and their value as a resource, special care would be taken to avoid encountering grizzly bears or disturbing their den sites. The effects of permanent-road construction on small mammals and muskrats are expected to be minor.

Any interference from airstrips would be limited to the movement of reindeer on Richards Island and in the Parsons Lake area. Fixed-wing aircraft and helicopters should not disturb reindeer or grizzly bears during flights or at take-off/landing, provided certain flight patterns and minimum elevations are enforced.

Well clusters and processing plants would remove small amounts of land from production and use by mammals in the area. Facilities might prove obstacles to reindeer travel, but would only deflect, not halt, unherded movements.

Reindeer probably would not be seriously affected by noise or equipment. Bears could be expected to avoid areas surrounding facilities. No fox dens have been located in the proposed development areas. Ground-squirrel habitats in the Ya Ya Lake area would be lost through gravel excavation.

In summary, the only direct effect of the field gathering system might be on reindeer movements in the Richards Island and Parsons Lake areas. Overpasses would be provided, however, so the reindeer could negotiate the pipeline. Effects on grizzly bears and small mammals would be slight or none.

F. AQUATIC RESOURCES

The construction of roads would result in some siltation of aquatic systems. However, effect on the aquatic biota should be minimal. In the Taglu area, the expected small quantities of additional silt should not increase the turbidity of the waters beyond the normal range. In the less turbid waters of the Parsons Lake area, even small amounts of silt could produce changes in the aquatic ecosystems. To minimize this risk, precautions would be taken to prevent slumping and erosion along the road routes.

Properly maintained snow roads should have no adverse effects on the aquatic biota.

Stream and channel crossings for permanent roads would lead to increased siltation of the water body. For streams used by migratory fish populations, suitable culverts or bridges would allow unrestricted movement. Road and stream crossings could be expected to reduce the quality of habitats for a short distance downstream, but the severity of this effect would be reduced by proper bank stabilization.

The construction and presence of airstrips would cause some siltation in the immediate watershed. This limited input would probably not be enough to affect local aquatic communities.

Dredging channels to improve access would displace large volumes of bottom sediments, which might be expected to affect the aquatic communities downstream. Resultant increased turbidity and/or change in oxygen availability might possibly deter migrating fish.

Gravel excavation could be expected to cause minor siltation in Ya Ya Lake, but the effect on aquatic biota would be overshadowed by natural siltation from the breakthrough of a new channel into the southern basin.

Little siltation and resultant effect on aquatic resources is anticipated from construction of docks, or of pads for well clusters and gas plants.

Water for the gas plants would be drawn from large reservoirs, with little expected effect on the areas' aquatic resources.

Gaseous emissions, such as oxides of nitrogen and sulfur, would be released to the atmosphere in relatively small amounts, so that no adverse effects to the aquatic ecosystem are anticipated.

With the expected increase in personnel in the area and the accessibility of lakes, excessive angling could reduce or decimate some local fish populations - notably lake trout - unless controls were instituted. Regulations governing open and closed seasons, bag limits, or type of fishing might be needed.

G. ECOSYSTEMS

The proposed development would have a limited influence on the trophic level structure of the region, affecting especially the predators.

Energy dynamics of the area are based almost entirely on primary production. Herbivores and carnivores involve an almost insignificant portion of the energy in the community. The proposed development would remove approximately 0.08 per cent of the primary production of an area covering over a million acres. Community energetics would not be seriously affected by this loss.

Habitat loss from the proposed development might reduce animal abundance, but should not alter the dynamics or basic structure of populations in the study area. Continued harassment of nest birds - especially geese - and of grizzly bears could destroy or reduce these populations.

The proposed development would alter or create new habitats into which organisms would move, resulting in some changes in diversity and succession over the long term.

H. HUMAN USE OF RESOURCES

The taking of geese and other waterfowl by native people of the three Delta communities of Aklavik, Inuvik and Tuktoyaktuk would be essentially unaffected by the proposed development, since the traditional hunting areas would not be directly subject staging areas, gas plants, clusters, or gathering systems.

Major boat traffic in hunting regions would be essentially at non-conflicting times of year. Controlled air traffic by the Applicants would not disturb flocks normally pursued by native hunters.

To the extent that local native people should accept full-time employment with the project, subsistence hunting might become less necessary and more a matter of choice.

The Applicants would not allow firearms at development or construction sites, thus avoiding direct increase in hunting pressure. However, construction or operations personnel could plan hunting trips for waterfowl from one of the Delta communities, thereby increasing hunting pressure.

The presence of proposed facilities should have little effect on any potential for tourism based on the area's wildlife resources.

Management of the reindeer herd could be complicated slightly by the project. However, encounters would be infrequent and should have little effect on the welfare of the herd.

The project would not directly affect the polar bear harvest, since the harvest areas are remote from the centres of activity.

Some increase in grizzly bear hunting by natives might result, because of the greater accessibility in the area provided by the permanent roads.

No reduction in fur-trapping potential is anticipated, as the acreage under development is small, and no trap lines in the area would be lost or destroyed.

The proposed development would not directly impinge on whale hunting in the area; hence no effect is expected.

Domestic or commercial fisheries should not be greatly affected by the development. Some overexploitation, possibly in Ya Ya Lake, could result unless controlled by regulatory measures. The potential for over-fishing is present to a lesser extent in other lakes on Richards Island, and perhaps in Parsons Lake.

The development project should not upset or seriously impinge on scientific research under way in the area.

The pristine state of the Delta environment would be altered by the addition of low levels of contaminants and by the physical presence of facilities. Development, however, would be concentrated in a number of locations, thus making the presence of the project less obtrusive.

V. ENVIRONMENTAL PROTECTION

The previous section identified those parts of the proposed development that could have long-range or permanent effects on the environment. Measures have been planned that would mitigate many of these potential adverse effects. The most prominent environmental concerns along with measures to minimize impacts include:

Siltation of streams in the Parsons Lake area

Slumping and erosion would be prevented by suitable construction and maintenance of roads. Culverts or bridges installed on streams used by migratory fish would allow the fish unrestricted movement.

Ice fog around gas plants

Under certain winter weather conditions, ice fog would probably build up near the plants. It should have no harmful effect on the local environment.

Loss of 750 acres of flood plain and upland habitats

Cluster drilling, along with centrally located gas plants, would minimize the land area used in roads, gathering lines and other installations. Site reclamation would be carried out to remedy any surface disturbance.

Effects on nesting birds and denning grizzly bears

Personnel movement and air traffic would be directed away from nesting areas. Locations of grizzly-bear dens have been identified and would be avoided.

As noted in Section III A, the project design incorporated a number of environmental protective measures derived from two years' intensive field study in the areas that would be concerned.

A. MONITORING AND SURVEILLANCE

1. Transient Activities

Personnel with a broad knowledge of the northern environment and a basic understanding of industry activities would be assigned to monitor all field activities during the pre-operations stage of development. They would report to an appropriate level of the Applicants' management, but be able to make judgments and decisions in the field. Through their management contact, they would have the ultimate authority to shut down field operations that should contravene the Applicants' and government environmental regulations.

Monitoring and surveillance measures for well-control, developed over the past few years of Mackenzie Delta exploration drilling, would be in effect for drilling of all development wells.

2. Long-Term Operations Activities

a) Gathering Systems

The central control station would include programmed computerized equipment to provide selective automatic shut-down of any part of the gathering system registering an alarm or emergency situation. The central control station computer would be programmed for automatic operation of a pre-determined shut-down procedure. Provision would also be made for manual operation or interruption of the shut-down procedure as required by the operator.

Besides the facilities at the central control station, independent instrumentation would be provided to protect and isolate individual sections of the system in case of an alarm, or a failure of the central control station system.

Continuous stress-monitoring systems might be installed at points where a design stress analysis showed that maximum stress levels could be expected.

The gathering lines would be equipped with pigging facilities capable of running internal wall-thickness checks on the pipe.

b) Cluster Systems

For production operations, wells would be equipped with safety valves both at the surface and below the base of the permafrost. Besides providing automatic shut-in for surface emergencies, the valves would be designed to fail closed in the event of severe subsurface damage. The critical functions of these valves would be monitored continuously at the central control station with its remote shut-in capability.

Well-cluster operations would normally be unattended, but well pressures, temperatures and flow rates would be monitored continuously by the central control station system. That system would also be able to monitor refrigeration systems and well-annuli pressures.

c) Plant Systems

The plants have been designed with simple process and mechanical flow. Therefore, simple control loops would be provided and the process would be able to operate within a wide range of turn-down. The central control station computer would monitor trends within the process systems. Corrective action would be taken by the operator, who would receive the necessary alarm indications.

As in the case of clusters and gathering systems, the plant instrumentation would activate shut-down before flaring. The flare tips would be continuously scanned.

d) General

A regular preventive maintenance and repair schedule would be developed, to minimize the possibility of failures due to poor condition of the mechanical components.

Monitoring of subsoil conditions would ensure that original design assumptions with respect to permafrost were being maintained. Thermistor cables would be installed at critical locations to record any changes in the temperature regime.

The local drainage patterns would be monitored to ensure that they were suffering no alteration that might affect subgrade or foundation conditions and lead to failure.

An air-quality monitoring station would be set up in the neighbourhood of each plant. Data from these stations would be monitored at the plant.

All critical functions of the life-support systems, such as water supply, electrical generation and sewage disposal, would be monitored.

Fire and security detection devices would be installed at appropriate locations in the cluster facilities. They would include intruder alarms on gates, doorways and windows, and a telephone would be provided outside the cluster fence for emergency calls to the central operations station.

B. TRAINING

Both formal classroom training, of the sort offered by the Northern Alberta Institute of Technology (NAIT), the Southern Alberta Institute of Technology (SAIT) and the Petroleum Industry Training Service (PITS), and training on the job have been required by the drilling, producing and gas processing industry for many years. Specialized courses have been the rule for certain segments of the industry that are subjected to seasonal shut-down.

A well-established course, which may come closest to meeting the requirements of environmental training for the arctic, is the annual training session and field trip for seismic personnel sponsored by the Forest Protection Branch of the Department of Lands and Forests. This course does far more than simply pass knowledge from the department forestry officers to the seismic crews. Over the years it has been responsible for a remarkable exchange of information between industry and the foresters, which has led to the development of geophysical exploration methods that are both more efficient and environmentally safe. This is the type of approach the Applicants would envisage as being most effective in their environmental training programs in the arctic, where they would be working with representatives of various government groups such as Land Use, Oil and Gas Conservation Board, Emergency Measures groups, and the Environmental Protection Service.

In drilling, production and pipeline operations, qualified personnel have been developed through the programs of PITS, with formal trades-training backup from NAIT and SAIT. All of these courses have emphasized 1) safety, 2) environmental protection.

Especially applicable to environmental concerns have been the oil-spill training courses by PITS. Now in their ninth session, they have provided a fair number of personnel trained to deal with oilfield environmental problems in the arctic.

With this background of training, and given industry's present environmental awareness, the immediate problem becomes one of demonstrating the special procedures required to ensure the survival of men and material under extreme arctic conditions, while safeguarding the environment in every way possible. The member companies of the Mackenzie Delta group are well equipped to demonstrate in lectures with visual aids the special problems of the arctic climate, and the sensitive nature of the environment associated with permafrost. Even with the generally careful programming of today's operations, there have been enough mishaps to convince the arctic newcomer that even the most careful planning and operation must be backed up by a contingency plan that provides for immediate and effective remedial action in any type of emergency.

The actual training schools would be developed and expanded in conjunction with a critical-path plan of the over-all project. This approach would ensure that all personnel could have the necessary training as early as desired, without the risk of classes too large for the instruction to be thoroughly assimilated.

A further advantage of gearing training-classes to the development program would be the steady incorporation of new-found knowledge.

C. CONTINGENCIES

Contingency plans are developed so that the operating companies can respond to any emergency. In these studies, contingency plans have been developed to deal with epidemics, transportation emergencies, prolonged isolation, fires, upsets of gravel and other bulk construction materials, and oil and chemical spills.

In the case of oil spills, the contingency plan developed for each operating area is based on two parameters - the source strength of the contaminant, and the sensitivity of the receiving body. In the Mackenzie Delta the source strength is finite, although the receiving body is generally sensitive. The absence of oil-producing wells and large-capacity oil-transmission lines precludes the persistent source: the problem then is to design systems that can handle a finite quantity - i.e., a known tank volume - whether it is stationary or transported on some vehicle.

Although the area is considered generally sensitive, the numerous lakes and ponds provide a water barrier to segregate the immiscible oil, so that the land masses become the more critical points. The problem will be further complicated by the fact that the scraping and grading techniques often used in the prairie regions to contain a body of oil cannot be used in tundra during summer. In winter, the standard shoed-bulldozer procedures can be used successfully, and the excess snow cover will be useful in containment and clean-up.

The moving waters of the Mackenzie river system present problems not encountered with the static lakes and ponds, but the very shallow gradients and resultant low current speeds are within the range of conventional floating-boom techniques. In the past two years, a good deal of experience has been gained through the Delta Environmental Protection Unit.

It is from these principles that detailed plans would be evolved for the drilling and production, gas-gathering, and plant-processing operations of the over-all Mackenzie Delta gas-development scheme. Detailed plans for each of these sections have been outlined by the respective departmental committees. The environmental considerations for all plans are reviewed below under the prime factors of "Source Strength" and "Receptor Sensitivity".

1. Source Strength

In all cases, the concern is with small volumes of refined products. As detailed plans are required in all drilling applications, they have been prepared for all well sites. The ones described were prepared for wildcat wells, but as the proposed project is in the development drilling stage, there would be fewer unknowns and the threat would be correspondingly less.

Cluster-drilling would mean a well-established fixed base, operated by trained crews that would spend longer in a given area. They would thus develop a better understanding of the emergency equipment stores and procedure and would thoroughly appreciate the sensitivity of the terrain.

The gathering systems and major pipelines would be on well-established routes and would therefore be subject to closer scrutiny, both in-house and by public officials - a condition that would tend to increase environmental awareness. This advantage would be even more apparent with the proposed gas-processing sites.

2. Receptor Sensitivity

Companies operating in the Mackenzie Delta recognized that normal scales of sensitivity and the equivalent spill-control programs

used in the south did not fully apply to the arctic scene. This difficulty posed a major problem in developing contingency plans for arctic oil-spills, but the addition of "Oil Spill Contingency Pre-Planning" for all wildcat drilling sites provided a solution.

The key point in planning was the judicious selection of an oil-spill jettison area, generally a lake close to the selected site, that had little or no aquatic life and a minimum of shoreline habitat.

The Slaney hydrology study provides the data necessary to complete the traditional "drainage-basin approach" to contingency planning, which was pioneered in Alberta in 1970 and has been followed throughout Canada for all industry contingency plans, especially in the production and pipelining phases.

The "Arctic Oil Contingency Plan for Gulf Oil Canada - Ecological Evaluation", provides the basis for developing detailed contingency plans for supply camps, well sites, gas field production, and plant construction and processing, for both the winter and summer conditions over the complete range of biological regimes encountered in the Delta. That report, as do several others by arctic investigators, repeatedly points out that, following the most careful physical-removal practices, land surfaces should be left to recover naturally from spills.

D. ENVIRONMENTAL LEGISLATION

The Applicants are conversant with existing environmental acts, regulations and guidelines passed by government, and would conduct all operations to conform with the intent of this legislation. Further, the Applicants would cooperate with appropriate government agencies to develop pertinent environmental regulations for hydrocarbon-production activities in northern Canada.

Pertinent legislation includes the following:

Arctic Waters Pollution Prevention Act & Regulations

Northern Inland Waters Act & Regulations

Navigable Waters Protection Act

Canada Water Act

Canadian Drinking Water Standards & Objectives - 1968

Clean Air Act

The International Convention for Prevention of Pollution
of the Sea by Oil (Canada Shipping Act)

Air Pollution Regulations (Canada Shipping Act)

Garbage Pollution Prevention Regulations (Canada Shipping Act)

Oil Pollution Prevention Regulations (Canada Shipping Act)

Oil & Gas Production & Conservation Act

National Energy Board Act

Existing Petroleum Refinery Liquid Effluent Guidelines

Interim Federal Contingency Plan for Combatting Oil & Toxic
Material Spills

Territorial Land Use Regulations (Territorial Lands Act)

Expanded Guidelines for Northern Pipelines

Canada Wildlife Act

Fisheries Act & Regulations

Migratory Birds Convention Act & Regulations

Canada Noise Control Regulations (Canadian Labour Code)

Canada Sanitation Regulations (Canadian Labour Code)

Territorial Game Ordinance & Regulations (N.W.T.)

Public Health Ordinance (N.W.T.)

General Sanitation Regulations (N.W.T.)

Camp Sanitation Regulations (N.W.T.)

Eating or Drinking Places Regulations (N.W.T.)

Historical Resources Ordinance (N.W.T.)

Fur Export Ordinance (N.W.T.)

